Navigation and Platform Development

Edgar An
Ocean Engineering
Florida Atlantic University
Boca Raton, FL 33431
Phone (954)-924-7231 Fax (954)-924-7233 E-mail: ean@oe.fau.edu

Grant #: N000149615029
http://www.oe.fau.edu/~ean

LONG-TERM GOAL

The long-term goal of this extended work is to develop and provide modeling and simulation (M&S) tools with which to characterize Unmanned Underwater Vehicle (UUV)-based mine reconnaissance mission analysis and help develop tactical decision aid.

OBJECTIVES

The main objective proposed herein is aimed at providing needed simulation capability to support U.S. Navy very shallow water (VSW) mine countermeasures (MCM) tactical decision aid development. Specific efforts include the enhancement of our existing Florida Atlantic University (FAU) 6-degree-of-freedom (DOF), nonlinear, simulation system model for the Ocean Explorer autonomous underwater vehicles with waves and currents effect, and characterization and quantification of the effectiveness of vehicle performance under a specific range of operational VSW scenarios using the enhanced simulation model.

APPROACH

We propose to enhance the existing modeling and simulation platform that has been developed at FAU. The enhancement consists of several aspects of the modeling and simulation of the OEX series Autonomous Underwater Vehicles (AUVs), including environment modeling. The approaches are described below.

WORK COMPLETED

The project was started in July of 1999. Thus far, preliminary communication was established with Coastal Systems Station for describing our M&S platform and its capability. The following is a list of work completed.

1. We cooperated with Penn State University on distributed simulation. So far, Penn State can run the FAU simulator (6 DOF AUV model) from their local machines, and connected to our vehicle through TCP/IP. All the commands that can be sent through acoustic modem in real mission now can be simulated and sent from Penn State.

2. We attended a 4-day High Level Architecture (HLA) Hands-On Course in August, 2000. The course was in Virginia and was sponsored by Defense of Modeling and Simulation Office (DMSO). The course provided a practical programming experience with the concepts of HLA and the Run-Time Infrastructure (RTI). The course also familiarized the Modeling & Simulation developers with the services provided by the RTI, and demonstrated strategies on how to implement HLA into their projects and achieve HLA compliance. http://www.virtualtechcorp.com/hop/

3. We refined the single vehicle Hardware-In-the-Loop implementation. A low-level sensor data interface for simulating raw sensor measurement was incorporated in the simulation such that another layer of the vehicle software can be tested in simulation. The simulation now is capable of switching between raw sensor measurement interface and processed sensor measurement interface.

4. A simple current and a 2D wave propagation model were developed and being used in the simulation to further improve the fidelity of the environment simulation. The wave was modeled as stochastic process over time and space with a predominant globally defined direction. Amplitude spectra from VSW data (available to the Naval Postgraduate School (NPS) through the oceanography department) was used to generate time histories of surface elevation change. Linear wave theory was used to propagate the fluid particle velocities and accelerations to the bottom. Wave forces were also added to the vehicle models.

5. A common environment structure and interface for multiple vehicle co-operation. This common environment interface only includes current and wave model, but can be expended to include acoustic propagation and bathymetry in the future.

6. We completed the prototype development for Multi-Hardware-In-the-Loop simulation. The objective of Multi-Hardware-In-the-Loop simulation is to provide modeling and simulation tools for multi-AUV corporations. A typical Hardware-in-the-Loop (HIL) simulation involves a Linux workstation and an AUV. The former runs the AUV model and generates the sensor data. The latter runs all the embedded vehicle software on a QNX operating system. The Linux workstation sends sensor information to QNX, and QNX sends back the rudder, stern plane and propeller revolutions per minute (RPM) information to Linux. Multi-HIL simulation involves several Linux workstations and vehicles. The communication among different Linux workstations and different vehicles are described in the following figure. All the Linux workstations need to synchronize with the environment information through TCP/IP connection. See Figure 1.

7. An automatic data interface was developed such that the AUV mission data file with FAU format can be automatically translated into MEDAL format. This effort was carried out in conjunction with Tony Healey's group at the Naval Postgraduate School. The program was successfully tested during the Fleet Battlelab Experiment - Hotel (FBE-H) rehearsal in Ft. Lauderdale and during the Fall FBE-H in Panama City, Florida.

8. A generic hydro code for AUV 6 DOF model was implemented as part of information separation for AUV modeling. The new model structure decomposes different information from different sources into different modules to avoid interconnection among sources. Specifically, AUV model data (AUV states), sensor data (including GPS data) and environment (wave and current) data were separated into different modules. Each module reads and writes information from and to the shared memory only. This development not only facilitates other software development and debugging,

but also simplifies multiple Hardware-In-the-Loop development since environment information is critical in multi HIL simulation. See Figure 2.

9. A prototype of the Transport Layer and the Network Layer for the communication of multi-AUV was developed and in testing stage. The objective of the multi-AUV communication project is to provide vehicles with a mean of sharing information in real-time during the mission. To achieve this, the communication protocol is grouped into several layers. See Figure 3 and 4. An important issue in multiple AUV communication is that when two AUVs are too far to each other. In this case, certain routing strategies have to be adopted. Network layer will handle this case and set up an indirect link between two vehicles.

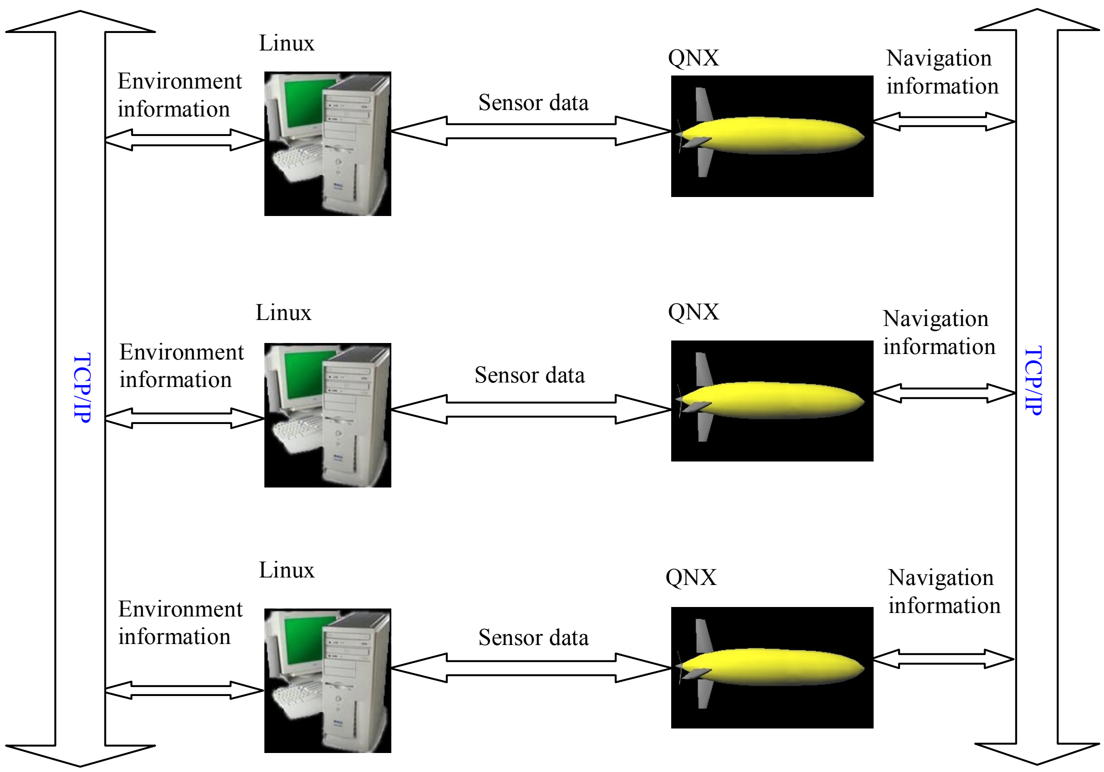

Figure 1. Multiple Hardware-in-the-Loop Simulation.

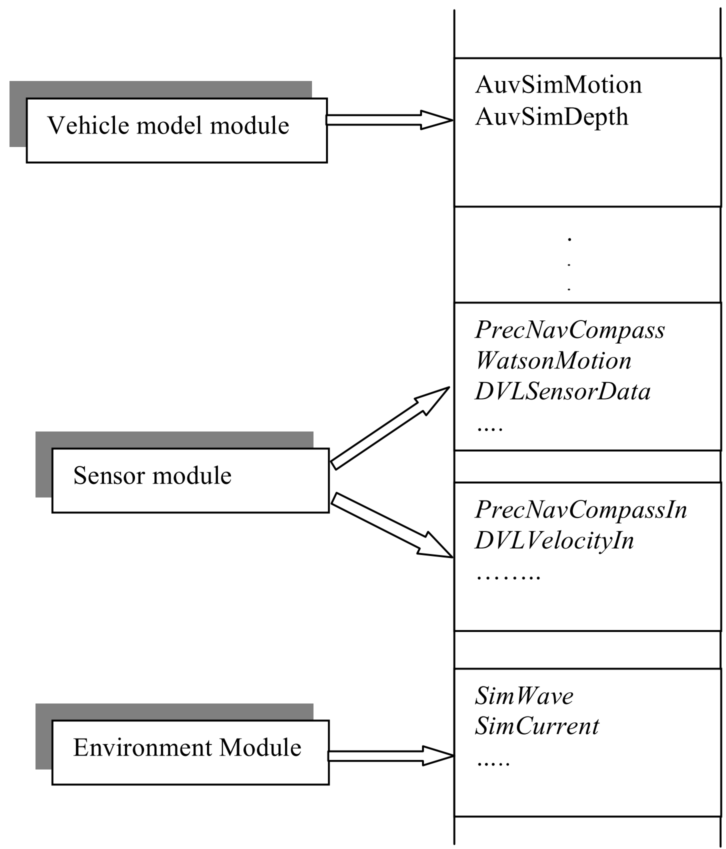

Figure 2. Data Separation for a Generic AUV Model

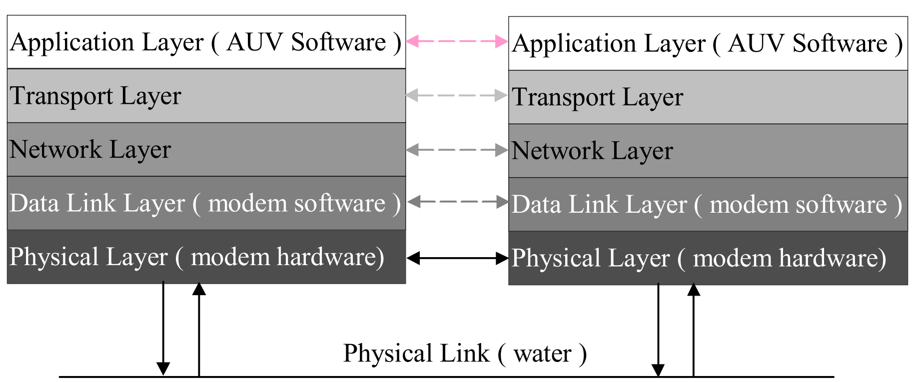

Figure 3. Protocol Layers for 2 AUVs

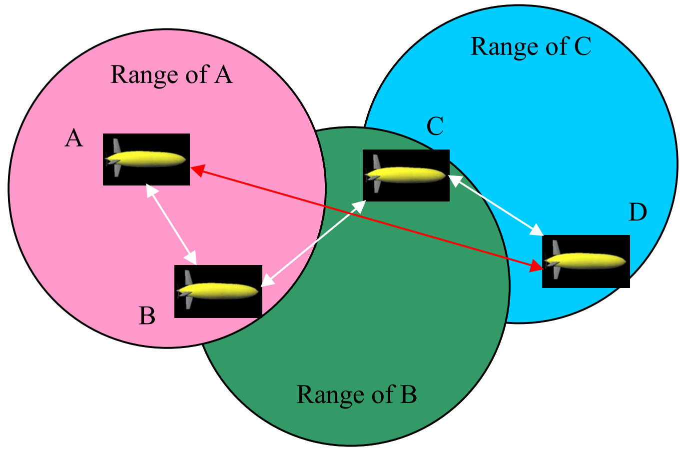

Figure 4. Indirect Link Between AUV A and AUV D

RESULTS

See section Work Completed.

IMPACT/APPLICATION

The M&S-based system tools are expected to reduce the system cycle time for devising a mine-reconnaissance mission plan using UUVs in very shallow water environment. With rapidly growing technology, the maturity of M&S will reach a new level at which high-fidelity scenarios can be evaluated and better tactical decision aids can be generated.

TRANSITIONS

None.

RELATED PROJECTS

This project is closely related to the AUV projects at Florida Atlantic University. M&S platforms can be used to develop, test and debug system software, and to characterize system level performance by means of hardware-in-the-loop implementation.

REFERENCES

Frederi Mahieu. Software Development of a Hardware-In-the-Loop Simulation and a 3D Viewer for Autonomous Underwater Vehicles, Master thesis, Florida Atlantic University, 2000.